

AMSAT Space Symposium 2012

AMSAT *Fox* Satellite Program



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Topics



- Background
- *Fox* Launch Strategy
- Overview of *Fox-1* Satellite

Background



- AO-51 was the most popular ham satellite
- Could be worked with simple equipment - HT and “arrow” antenna
- Widely used in scouting, educational and demonstration events
- Failed in November 2011
- Need replacement ASAP!

Fox Launch Strategy



- Take advantage of large and growing interest in CubeSats
- Develop family of CubeSats with ham radio transponders that are attractive for hosting science experiments
- Partner with universities to develop science and education missions
- Get free launch from primary mission via grants or NASA ELaNa program
- After science mission completed, satellite becomes amateur radio transponder

CubeSat Technical Challenges



- Very small size (1U = 4" x 4" x 4")
- Very low mass limit - less than 3 lbs
- Limited surface area for solar cells - limited power
- Limited area for antennas

Fox Program Phases



- Phase 1 satellites (*Fox-1*)
 - 1U structure
 - FM repeater mode with sub-audible low speed data
 - Digital data mode up to 9600 bps
- Phase 2 satellites (*Fox-2*)
 - Probably 3U structure
 - Software defined radio transponder
 - Linear, FM and high-performance digital modes

Fox-1 ELaNa Proposal



- Proposal submitted to NASA for launch as an education mission - Nov 2011
- Penn State student experiment (MEMS Gyro)
- Requested orbit - 650 km
- Requested launch - 2nd Half 2013
- Accepted at priority 14 of 33
- No launch date yet

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Fox-based University Projects



- AubieSat-2 & 3
- RadFxSat
- NASA InVEST grant

AubieSat-2 & 3



- Proposal submitted for National Science Foundation grant
- Auburn, University of Alabama & AMSAT
- 1-year science mission - atmospheric physics
- Ham transponder after science mission is complete
- Response from NSF expected in November
- *Grants are highly competitive!*



RadFxSat



- NASA ELaNa proposal
- Vanderbilt University and AMSAT
- *Fox-1* flight spare
- Primary focus - Space Radiation effects test bed
- Secondary focus - STEM education



RadFxSat - Mission Profile



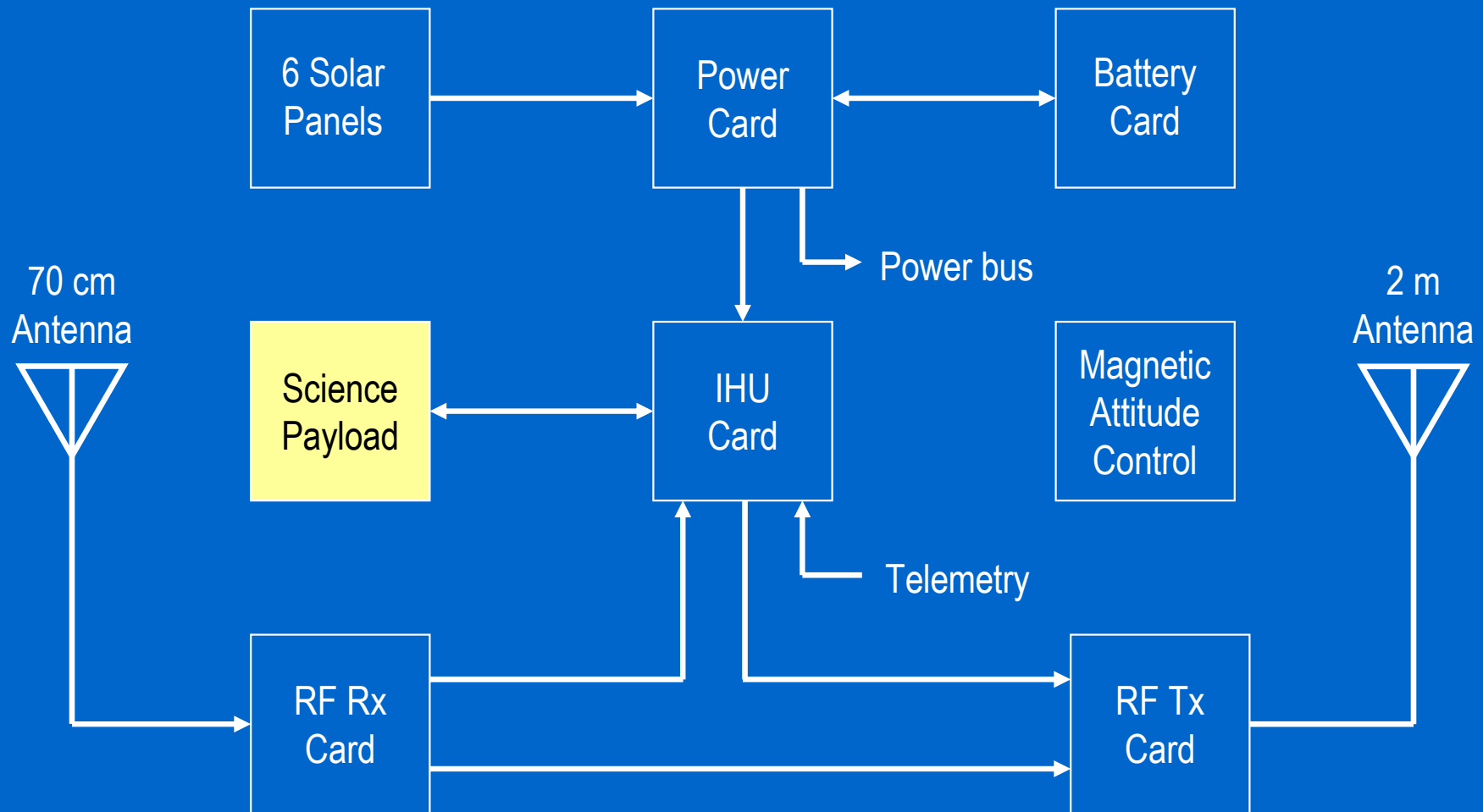
- Experiment payload runs simultaneously with amateur radio transponder
- Experiment data transmitted via low-speed downlink
- Requested launch 2H 2014
- Requested orbit - 650km (same as *Fox-1*)
- NASA ELaNa proposal due Nov 12
- Response expected Feb 2013

NASA InVEST Grant



- In-Space Validation of Earth Science Technologies
- Team of 2 universities and AMSAT
- Validate weather observation instrument
- Proposal due Nov 27
- Launch 2H 2015
- Selection expected by May 2013

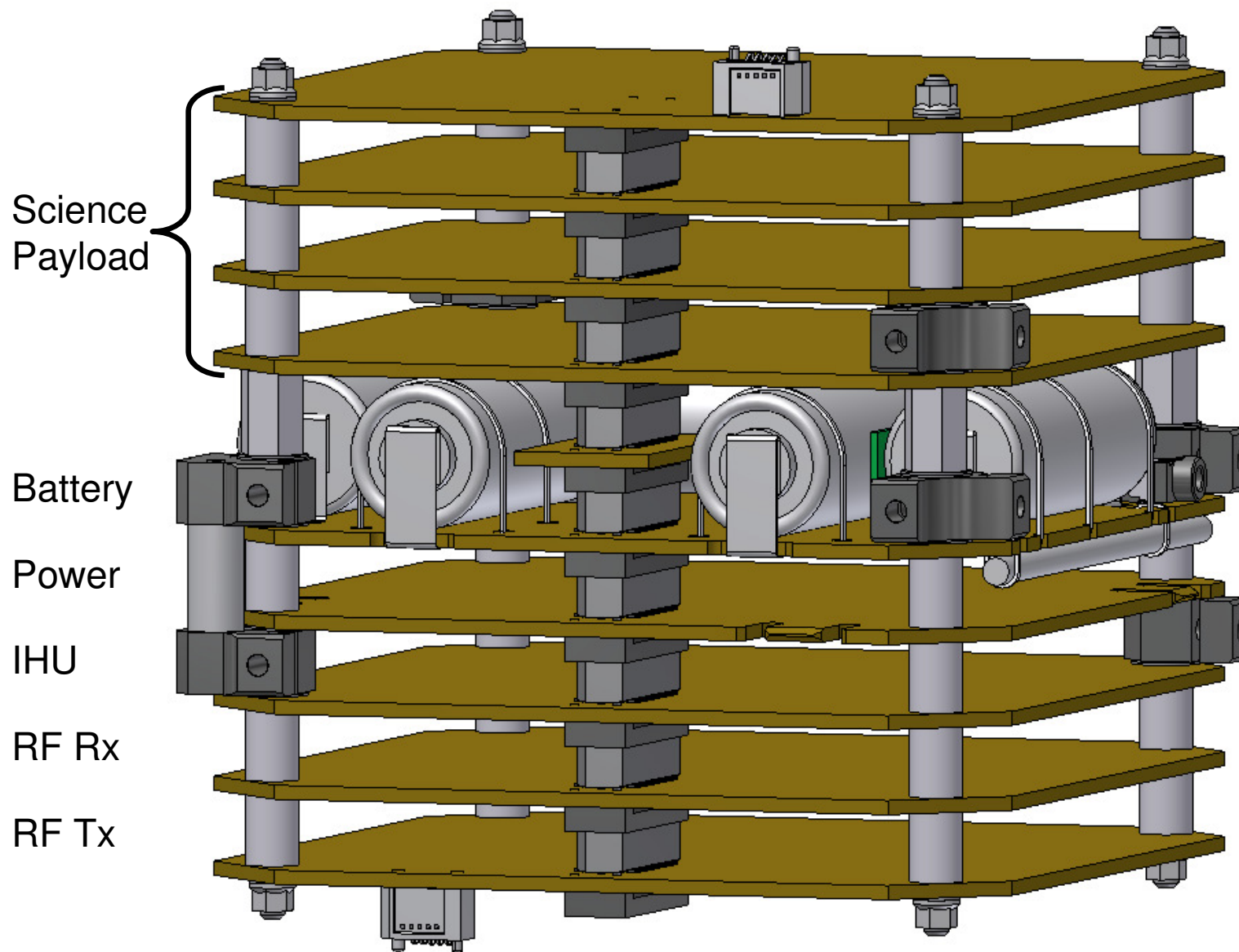
Fox-1 Overview



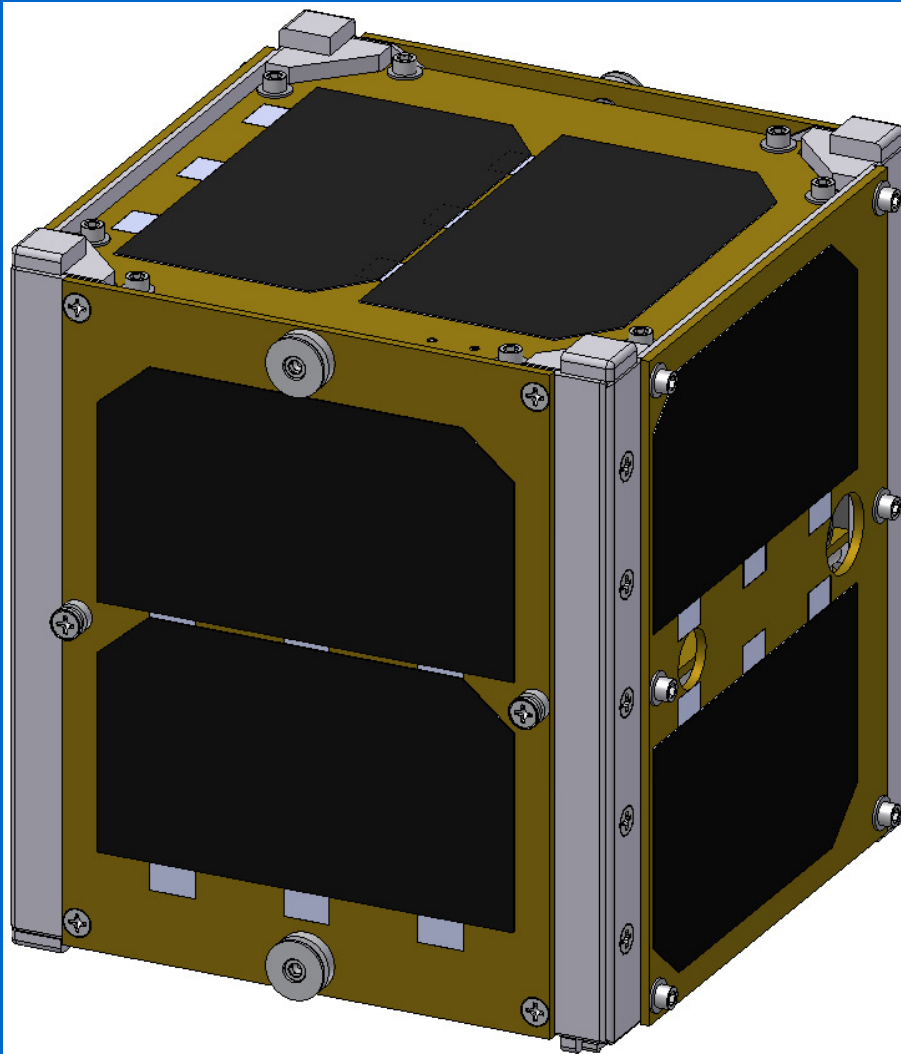
Avionics PCB Stack



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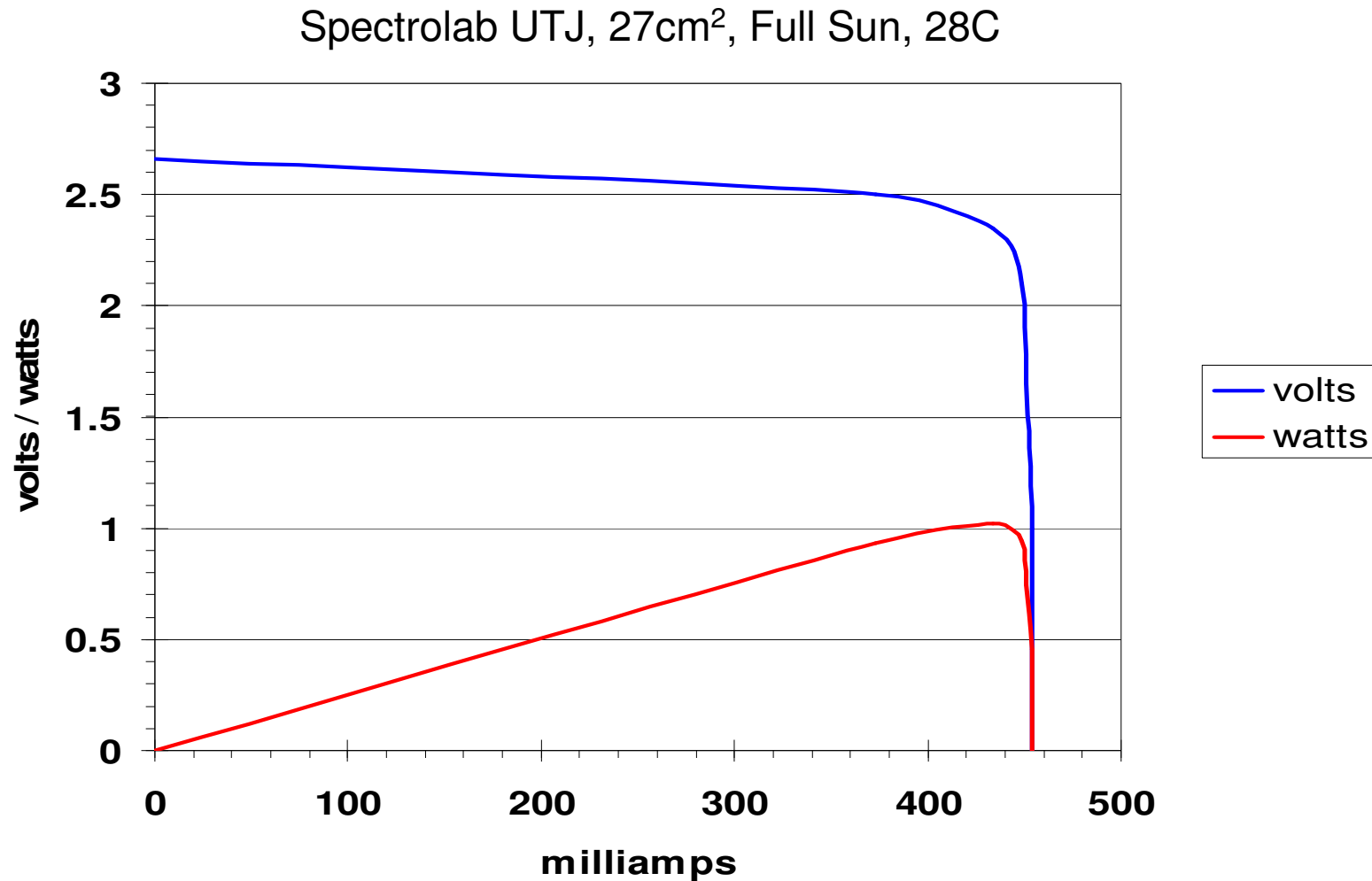


Solar Panels



- 6 solar panels
- 2 cells per panel
- Spectrolab Ultra Triple Junction cells
- Space-rated
- 28% conversion efficiency

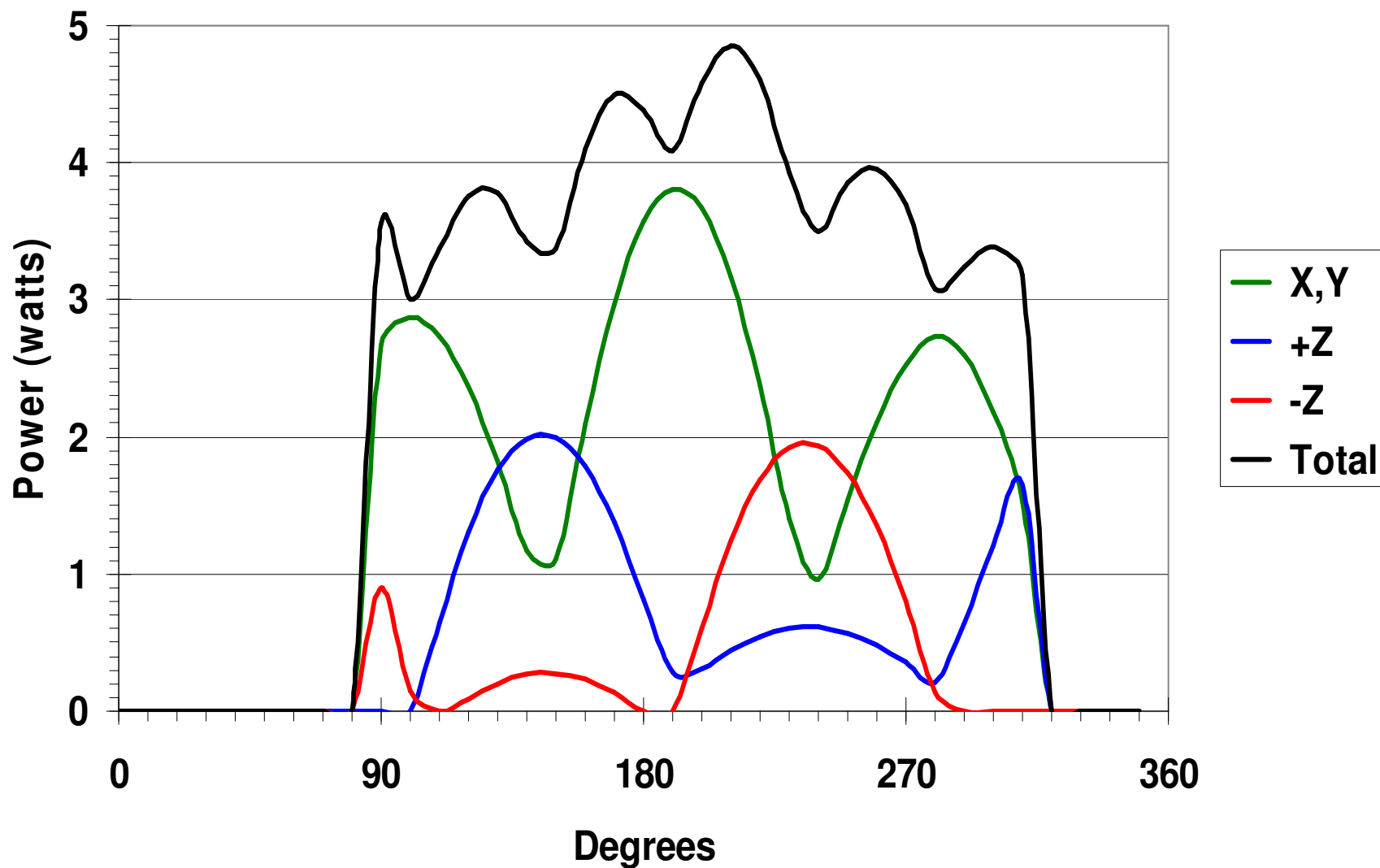
Solar Cell Characteristics



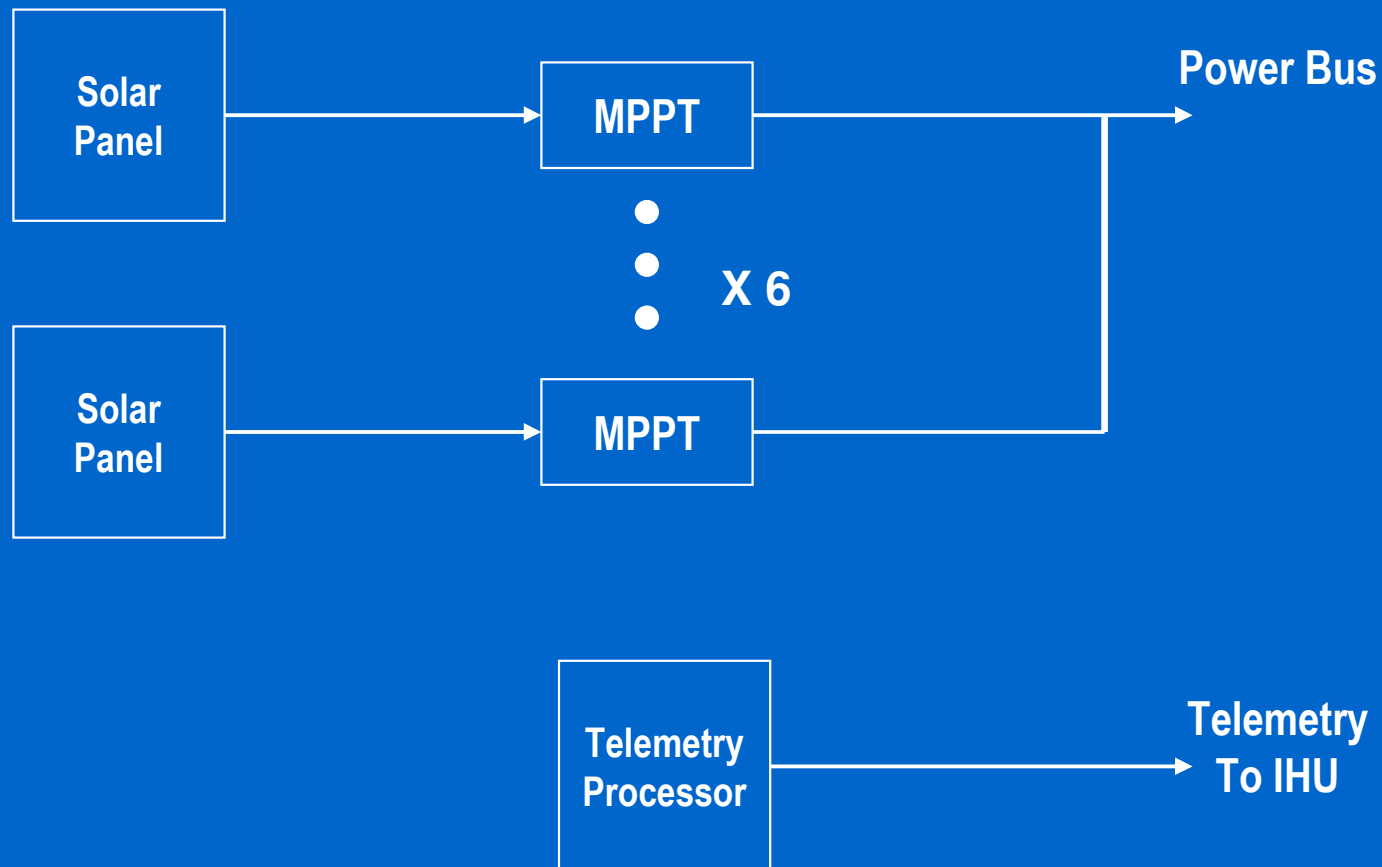
Generated Solar Power



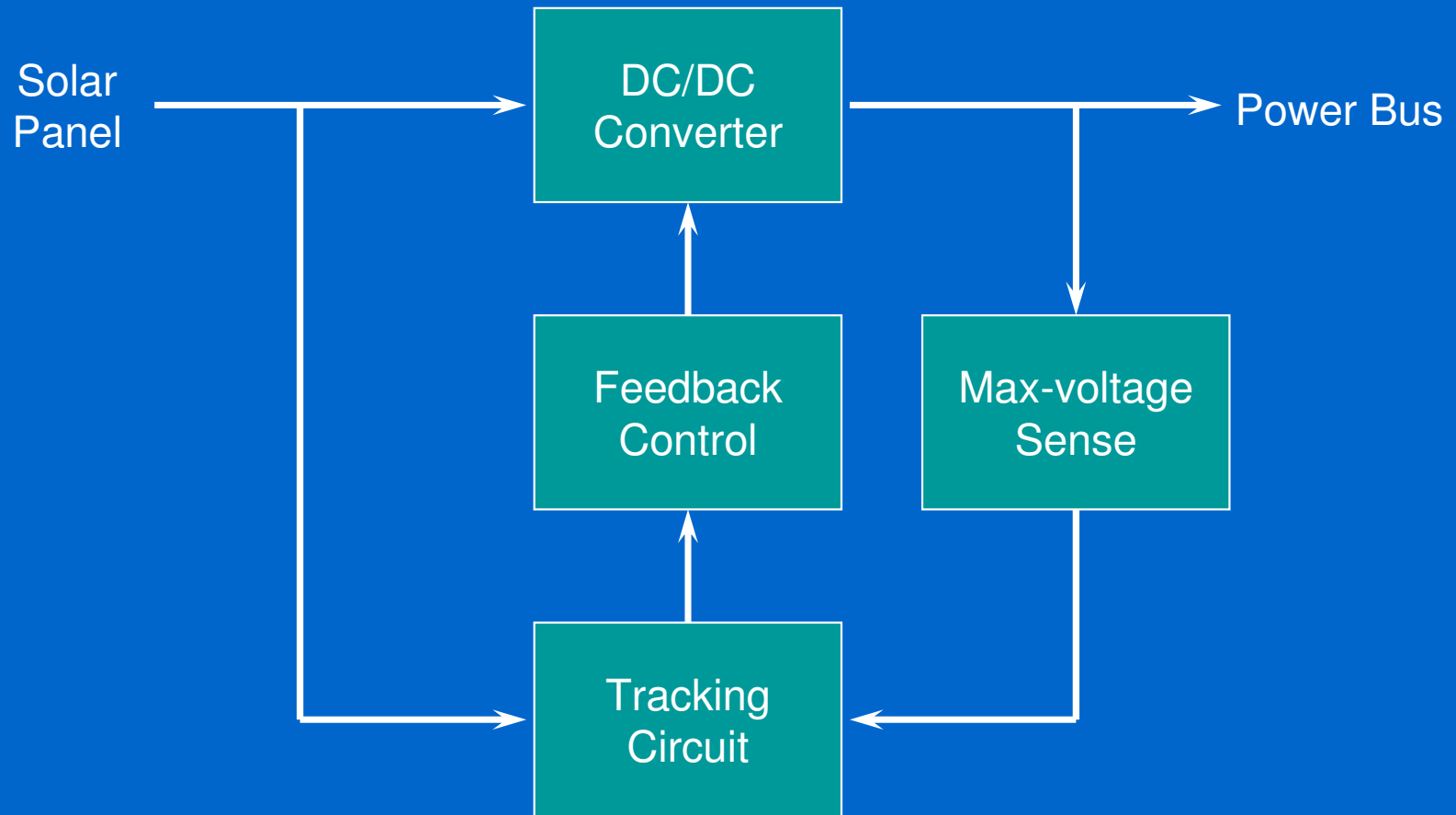
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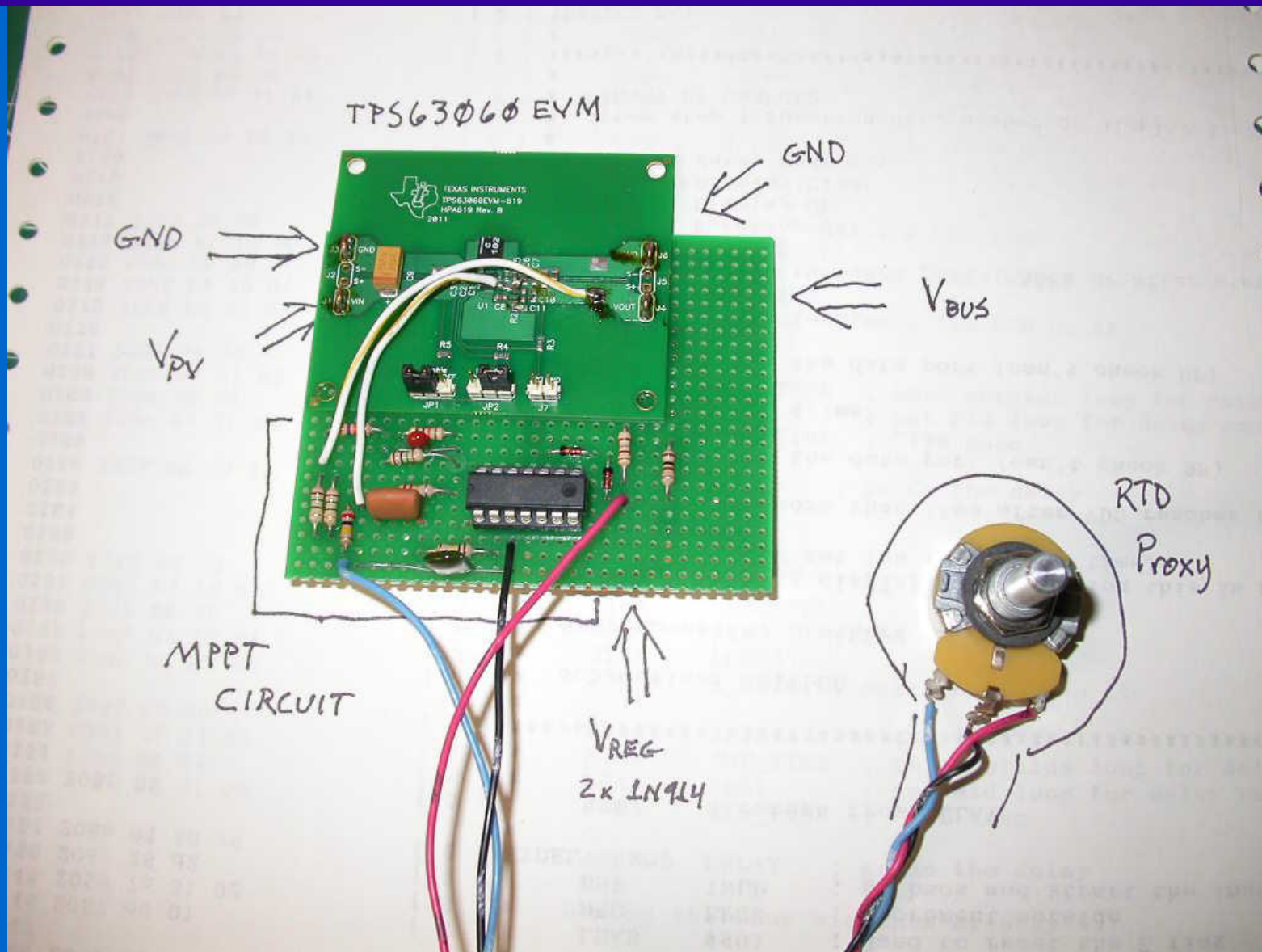
Power Card



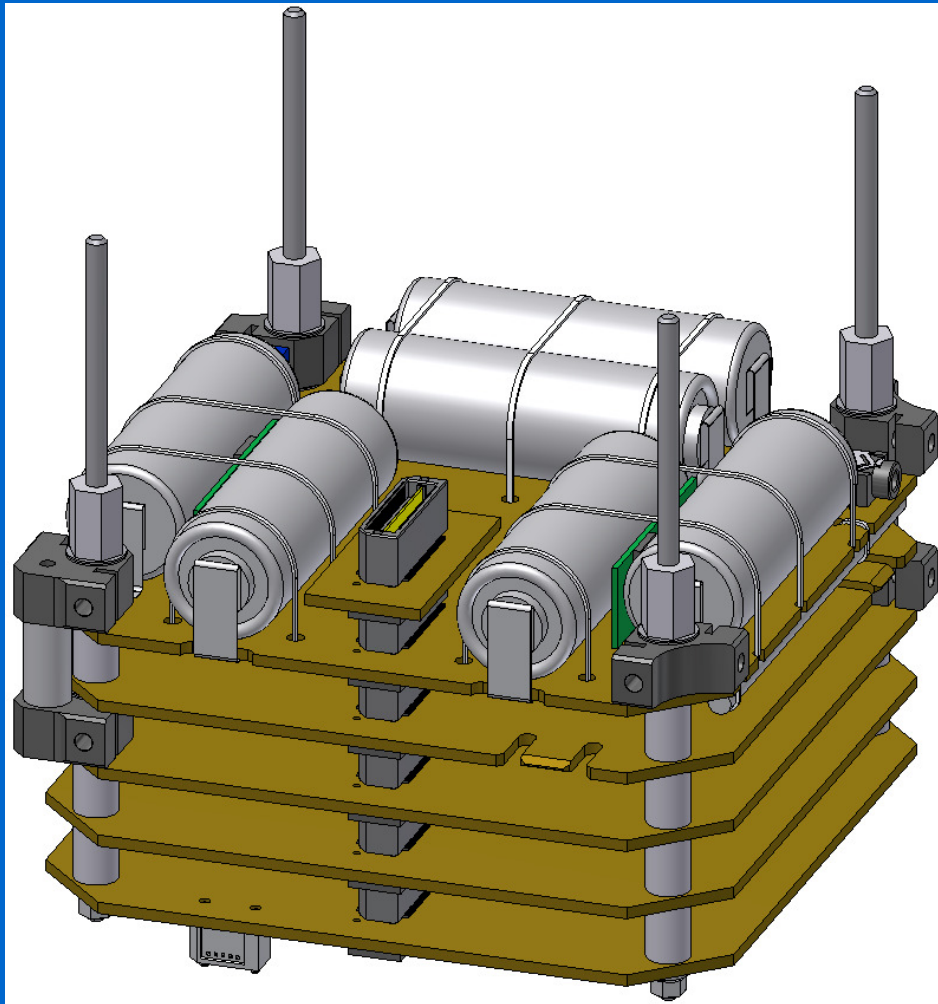
MPPT Operation



MPPT Test Circuit

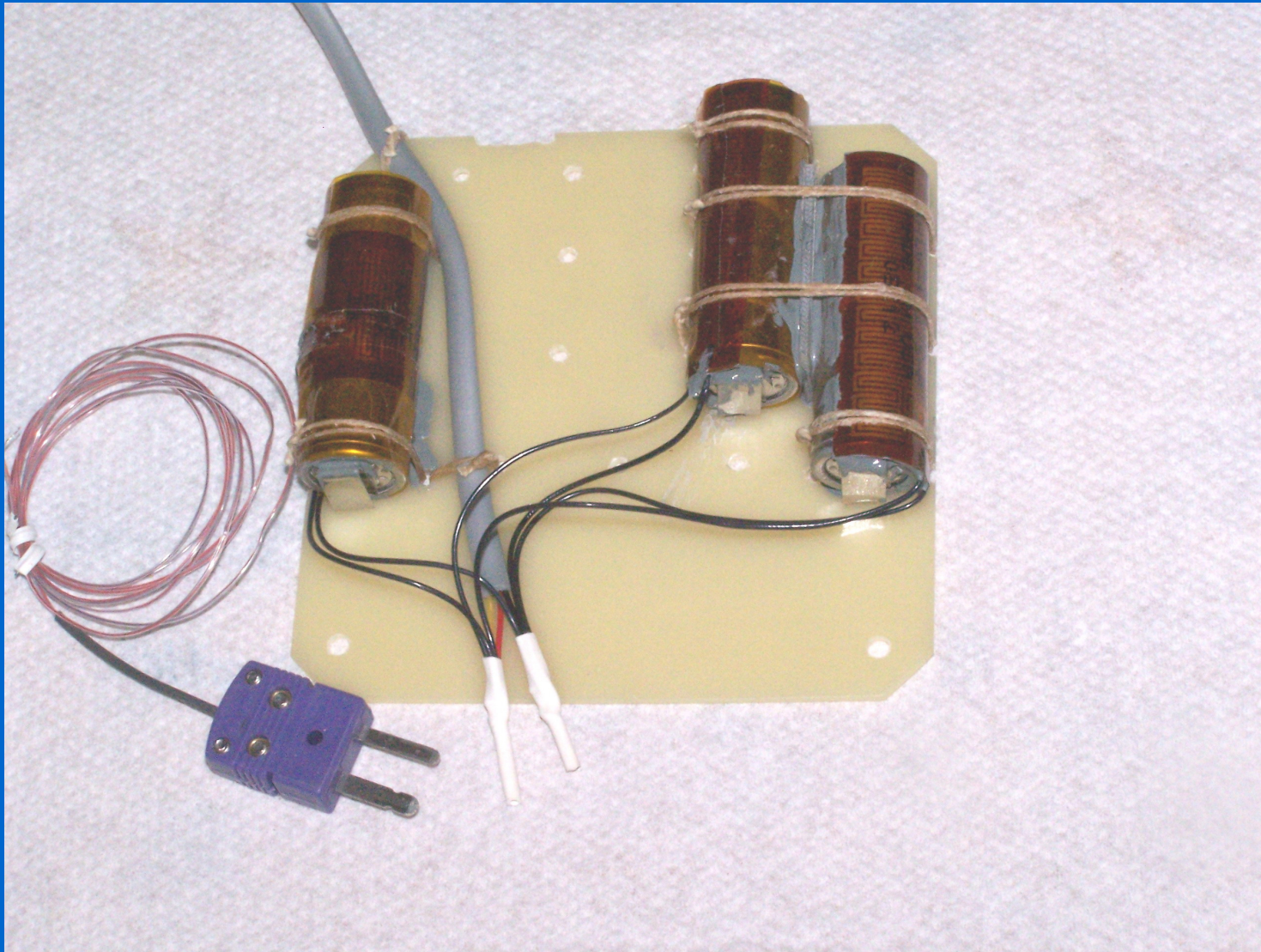


Battery Card



- 6 Cadnica (NiCad) A cells
- 3.6 V nominal
- 12 watt-hours capacity
- Battery protection circuitry
- Active thermal control
- Telemetry processor

Battery Heater Test Prototype



IHU Card



- Collects telemetry information
- Operates science experiment
- Sends telemetry as sub-audible low speed FSK in transponder mode
- High speed FSK in data mode
- Executes commands from ground control

IHU Card (cont)



- ST Microelectronics STM32L
- Ultra low power CPU
- 32-bit processor
- 33 MIPS
- 128K FLASH program memory
- 16K RAM
- 128K non-volatile Magnetorestrictive RAM
- Micro-SD card
- MEMs gyros for student experiment

IHU Software



- Open source SW tools (GNU C compiler)
- LINUX or Windows development environment
- FreeRTOS operating system
- STM32 "Discovery" card for SW development
- FreeRTOS running on Discovery card
- Drivers for I²C, SPI, serial ports running
- Modems for high and low speed data done in software

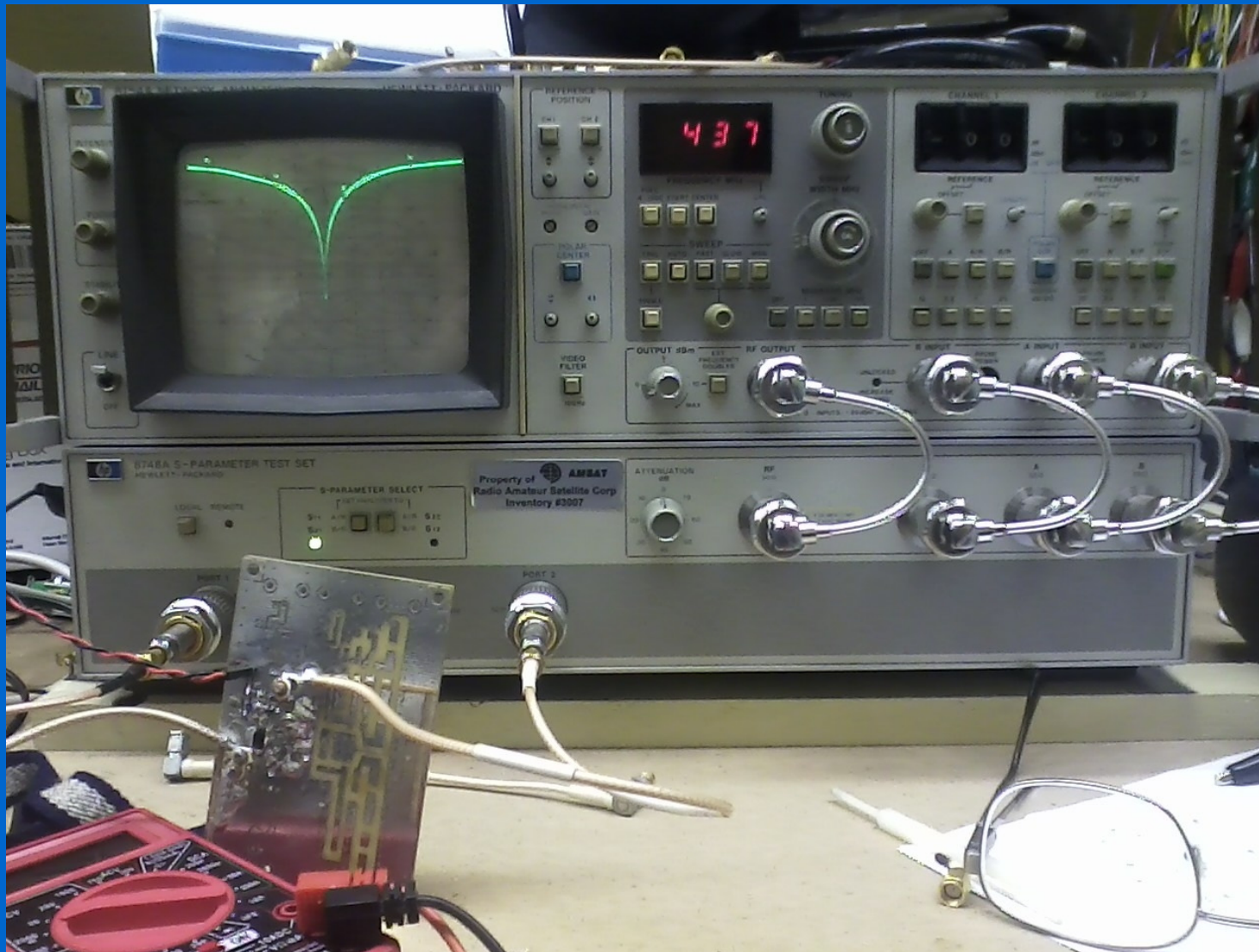
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RF Rx Card

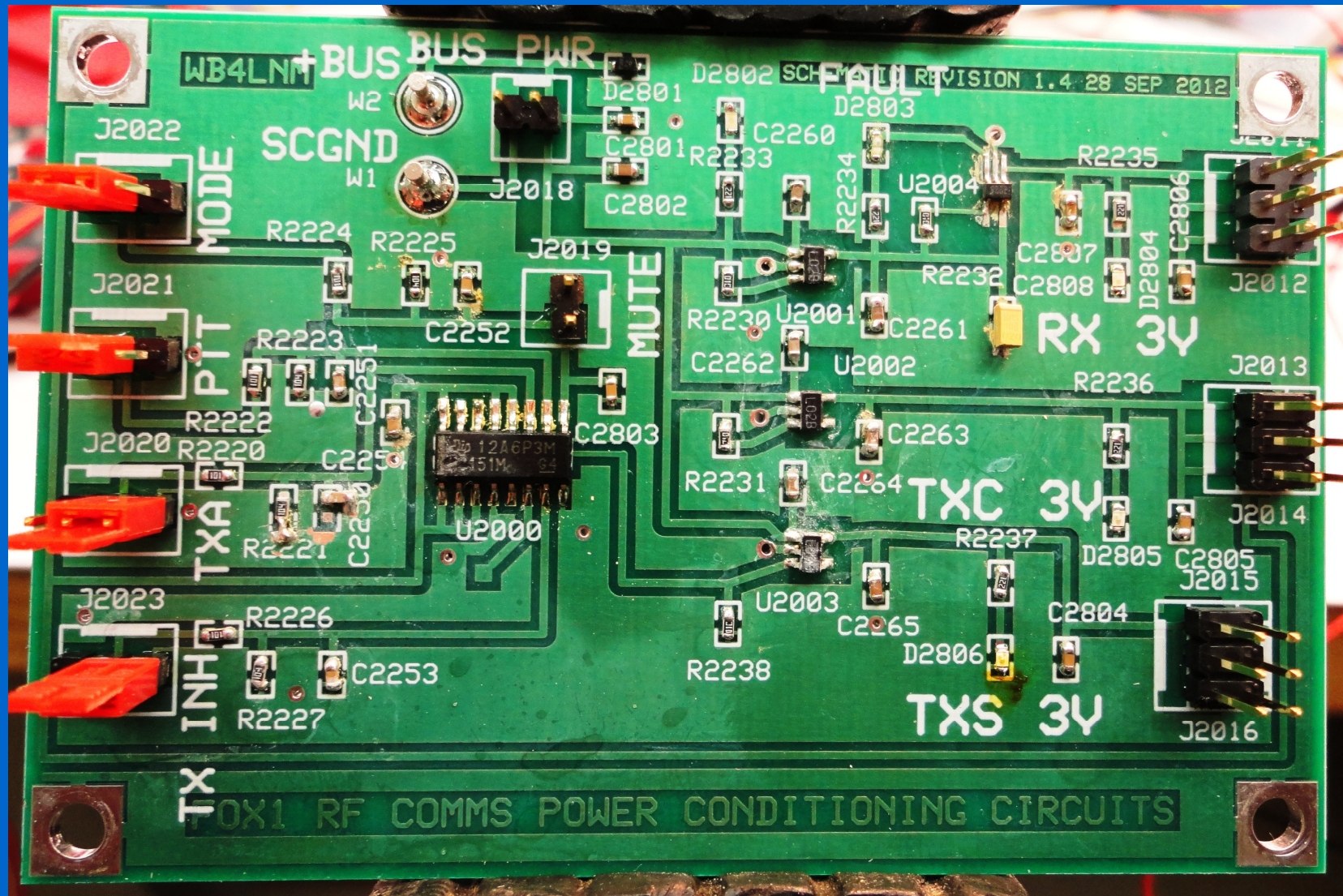


- Operates on 70cm
- FM receiver
- LNA with SAW filter for high sensitivity
- Automatic frequency control
- Provides audio to IHU and RF Tx

Low Noise Amplifier



Rx and Tx Power Conditioning



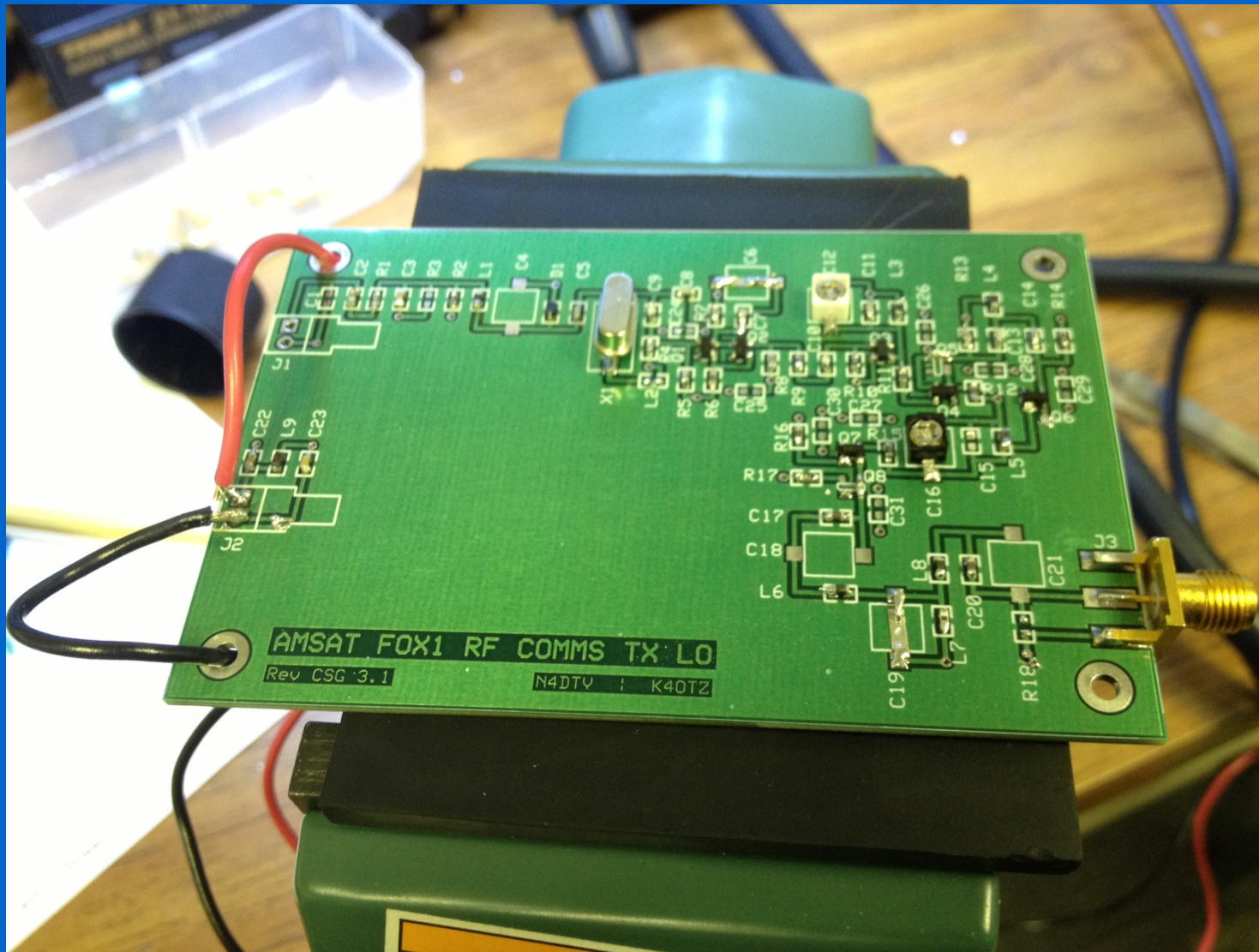
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RF Tx Card

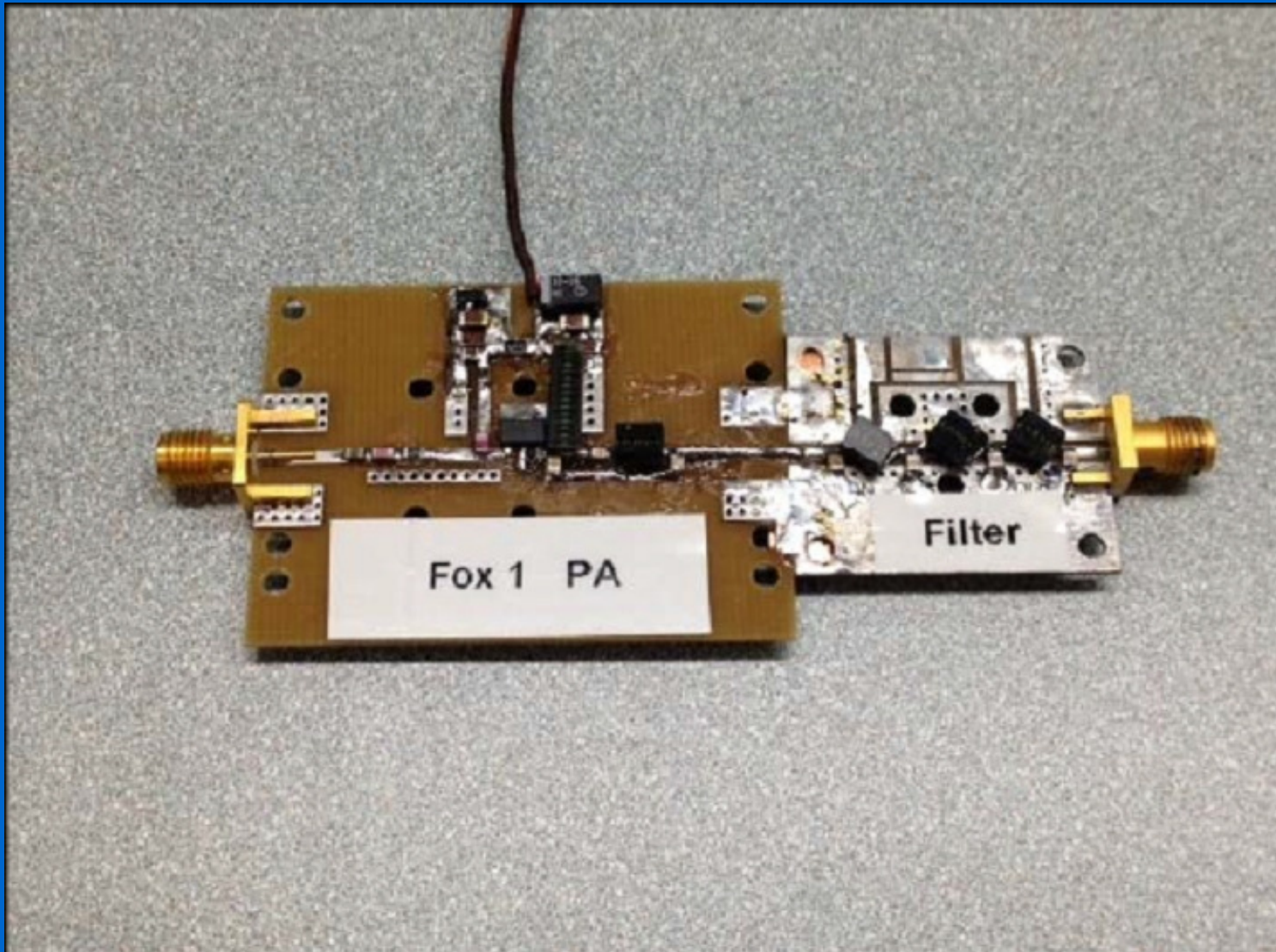


- Operates on 2 meters
- Inputs from IHU and RF Rx
- True FM exciter
- Power amp produces > 400 mW

Tx Local Oscillator & Modulator



RF Power Amp

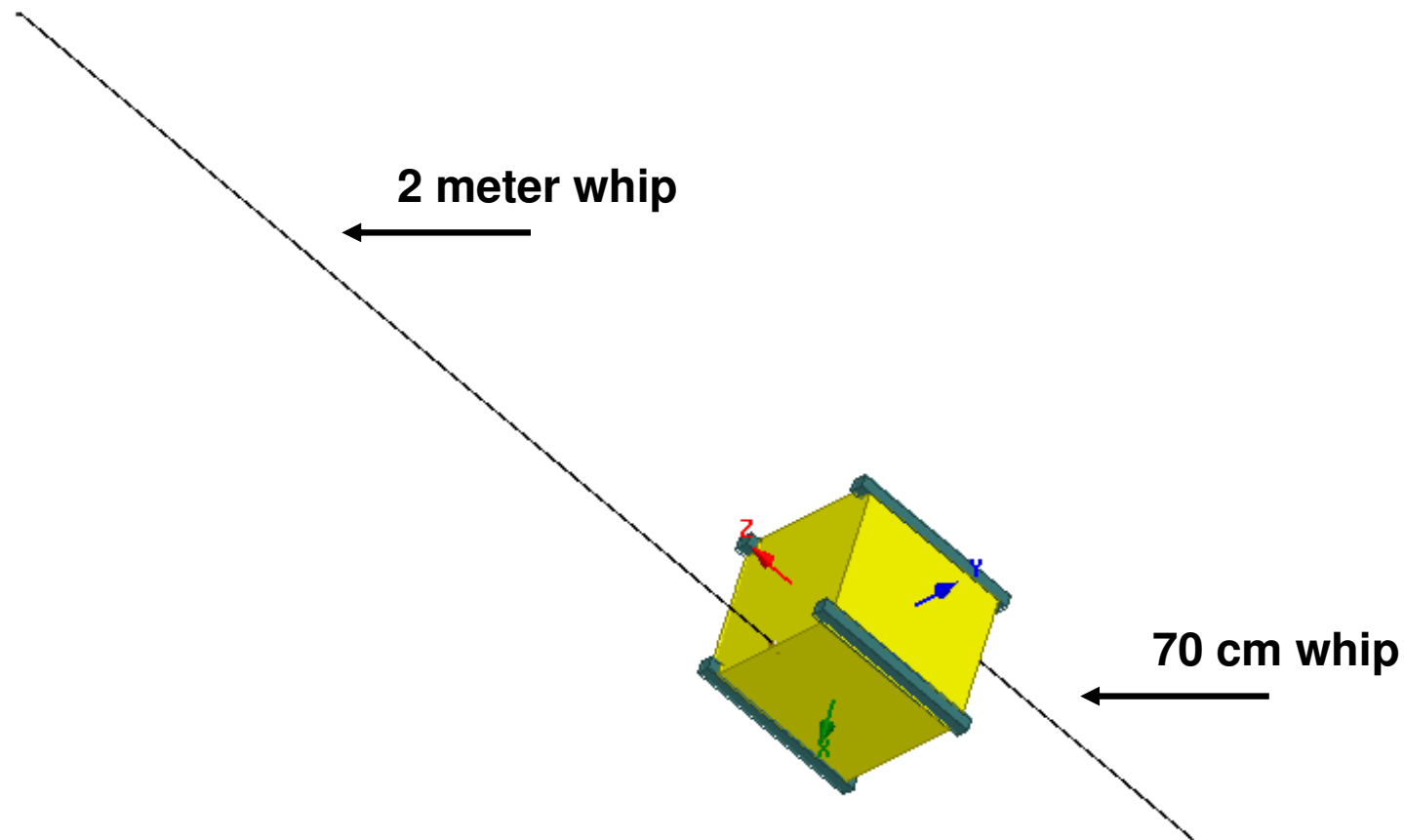


Attitude Control

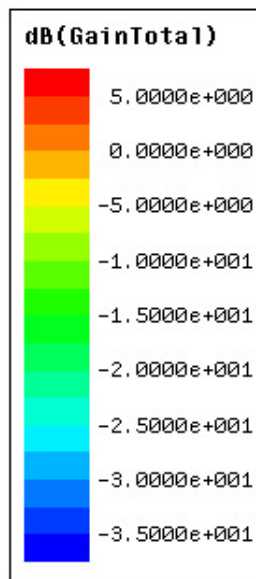


- Passive magnetic system
- Aligns satellite z-axis with earth's magnetic field
- Bar magnet on structure
- Hysteresis rods on battery card for motion damping

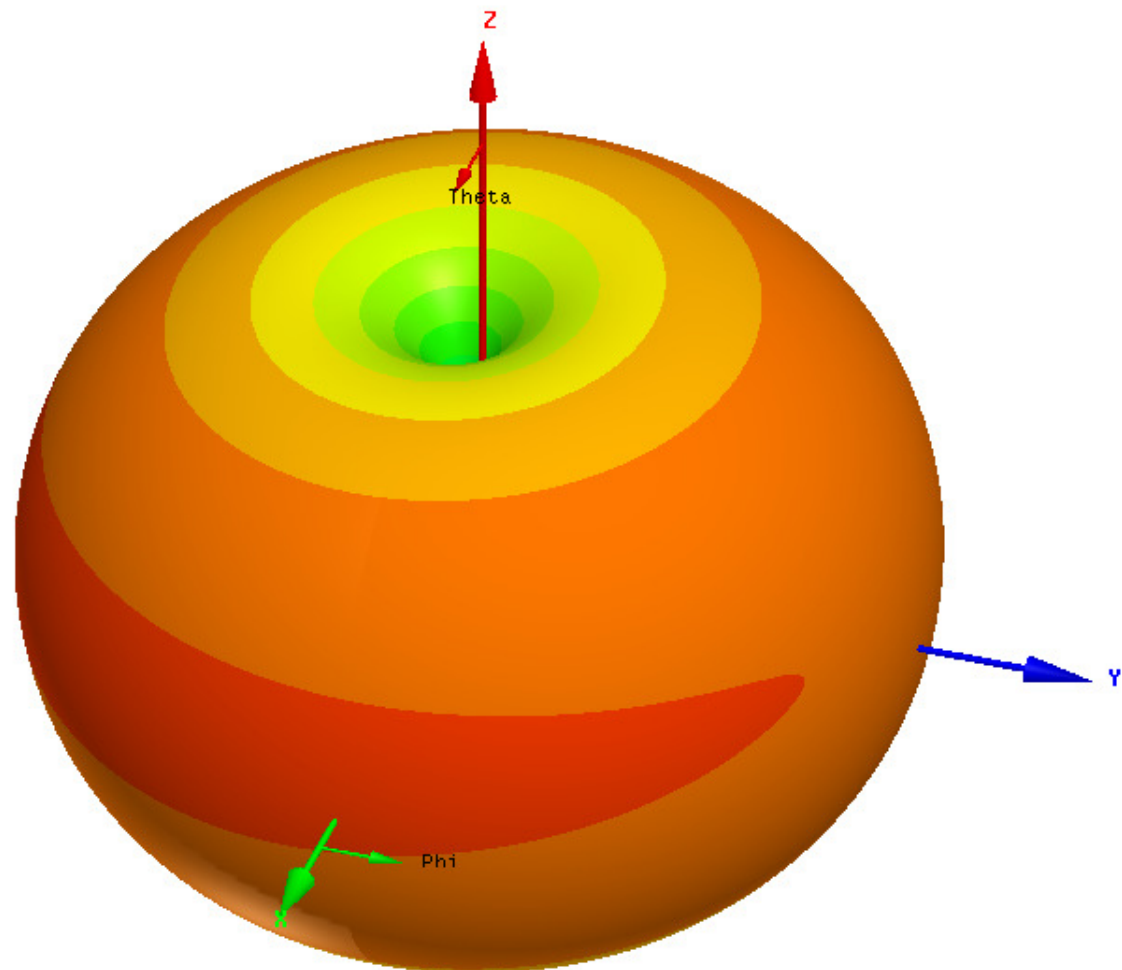
Antennas



VHF Antenna Pattern

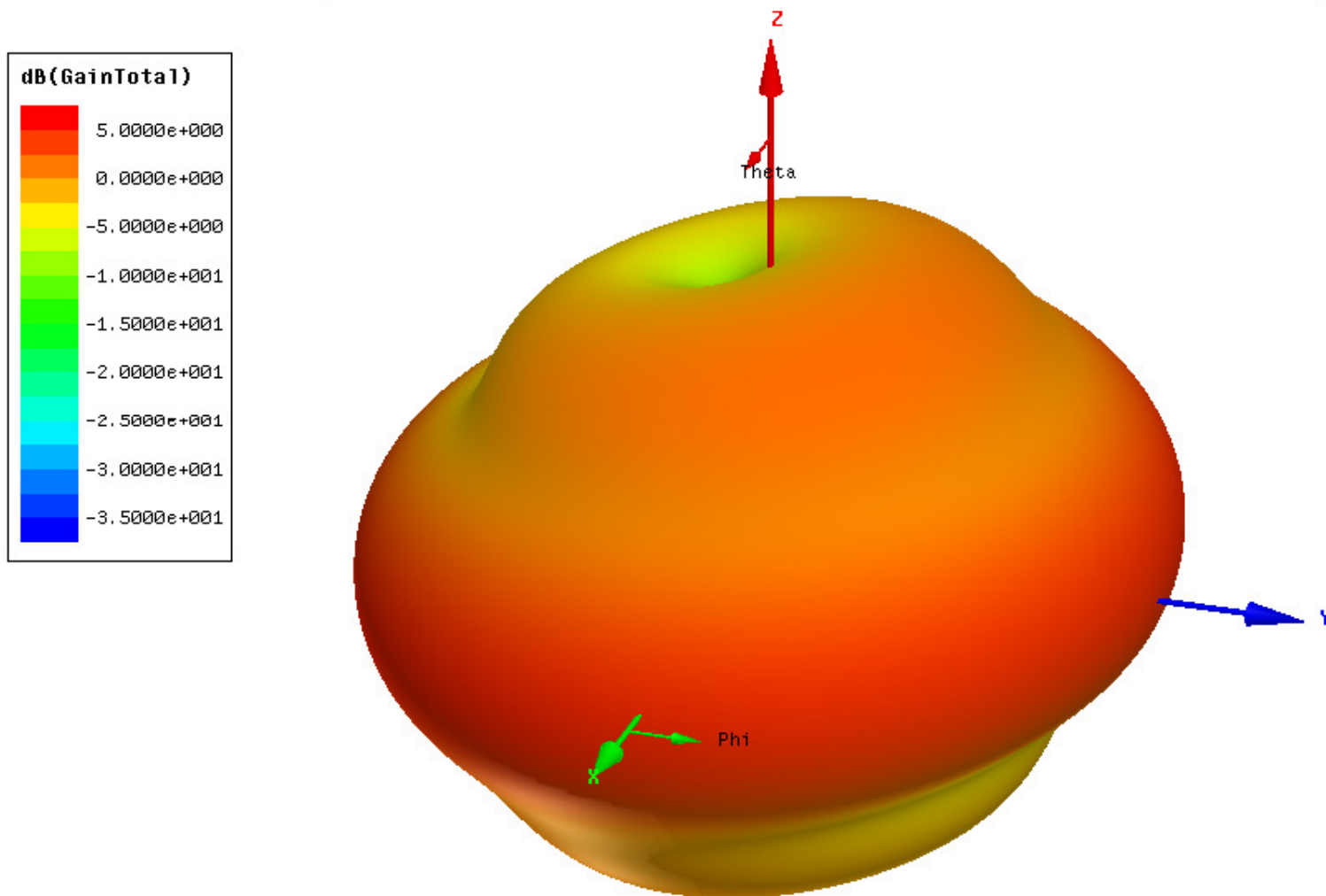


Cubesat: 2m (145 MHz) dB(GainTotal) versus Phi and Theta (09/17/11)

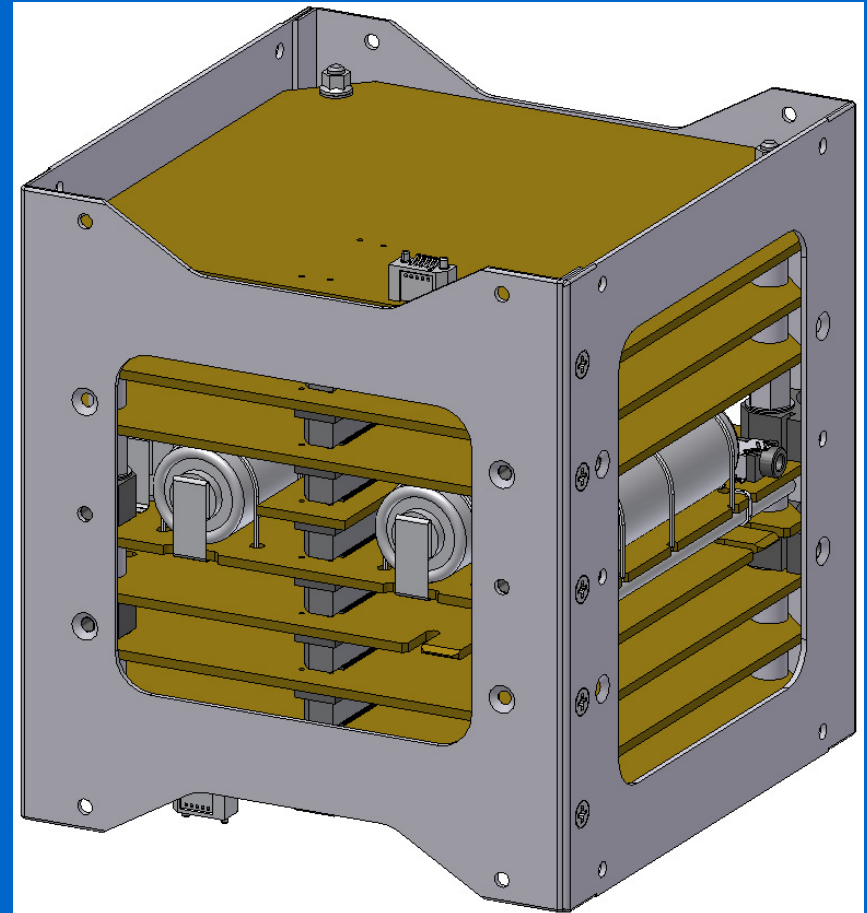
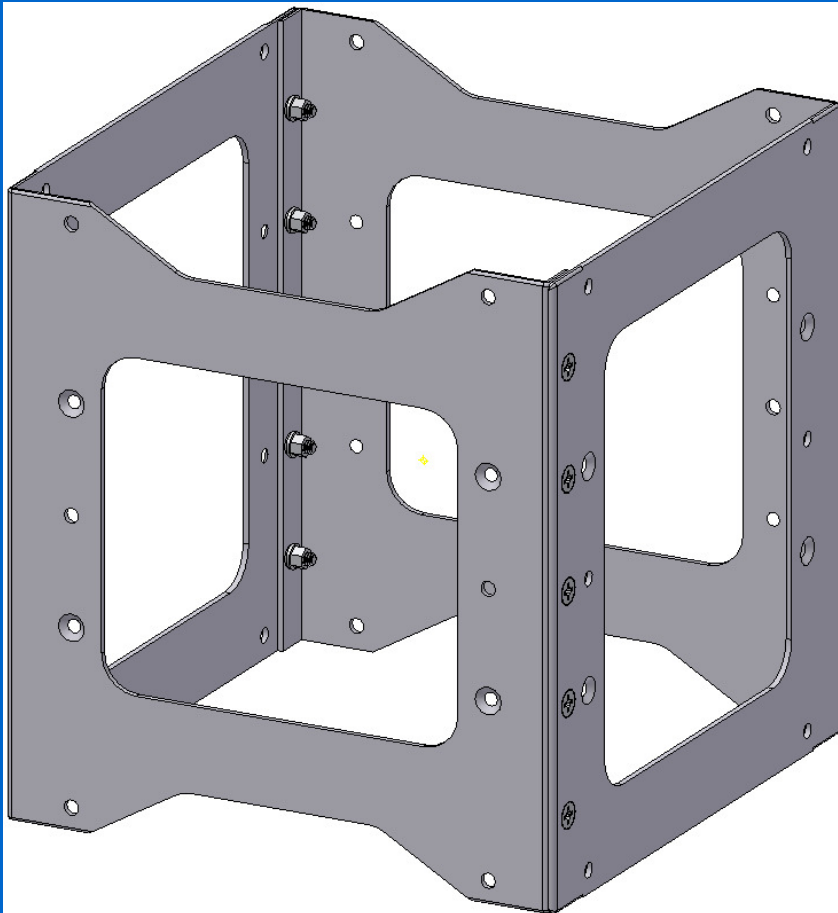


UHF Antenna Pattern

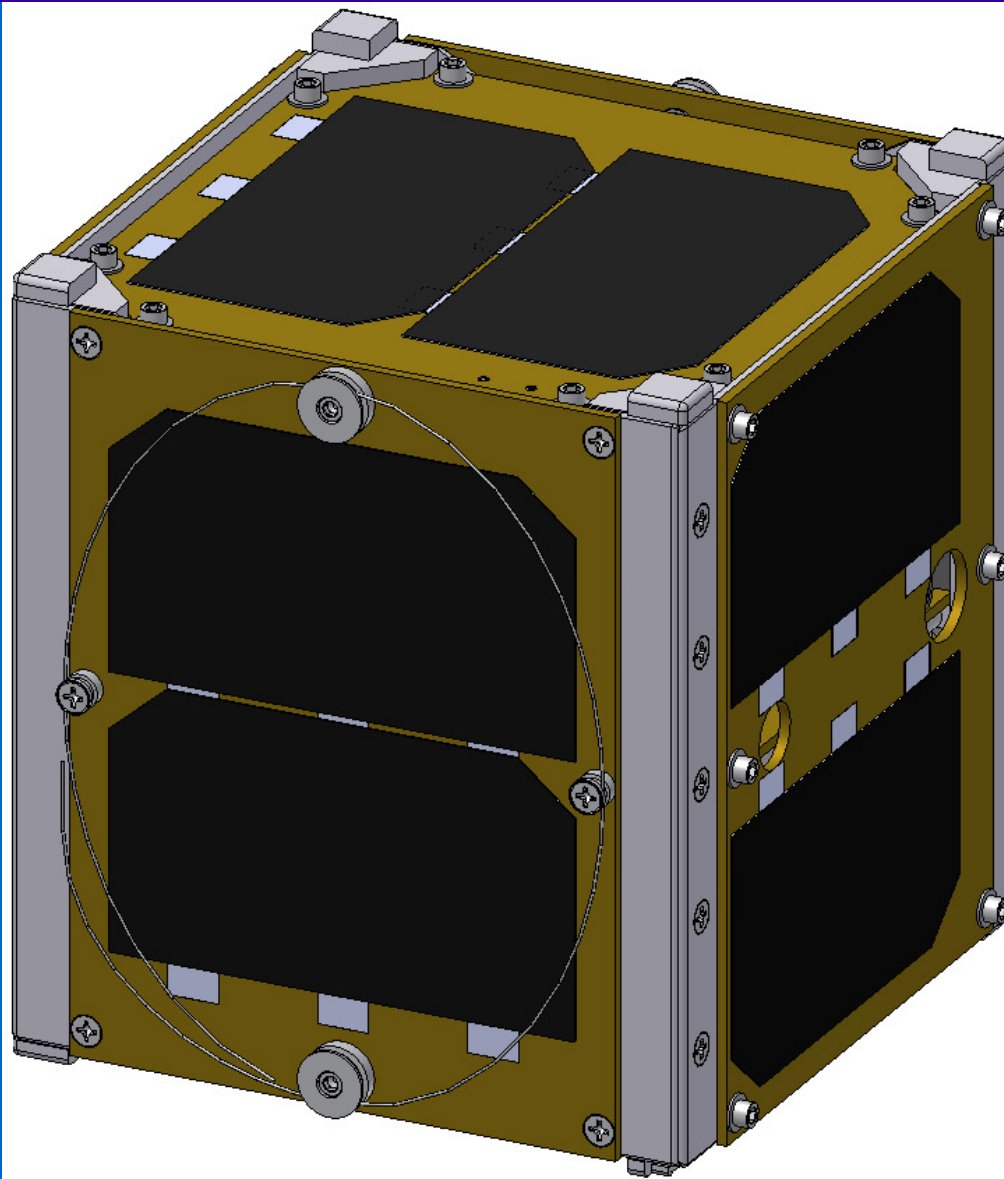
Cubesat:70 cm (435 MHz) Matched Pol. Gain versus Phi and Theta (09/17/11)



CubeSat Structure and PCB Stack



Assembled *Fox-1* Satellite



AMSAT Classifieds



*** **HELP WANTED** ***

AMSAT is always hiring!

- **Design engineering:** mechanical, electrical, PCB design systems, software, project management, thermal design
- **Satellite construction:** PCB construction, parts procurement, component fabrication, assembly
- **Satellite testing:** environmental testing, functional testing, requirements and regulatory compliance testing

Contact Tony Monteiro aa2tx@amsat.org

Any Questions?



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